DECLARATION

I, Toshiharu INOUE of Yakohama, Japan, the translator of the Japanese Application Ser. No. 0003083, do hereby certify to the best of my knowledge and belief that the herewith enclosed is a true translation into English of the corresponding copy of the document which has been filed with the Japanese Patent Office on January 10, 2001, with respect to an application of Letters Patent.

Signed, this 17th day of June 2002

Tm Inoue

Toshiharu INOUE

Literal Translation of
Application Ser. No. 0003083
for Ricoh Application EPP01-574

[Name of Document] Application for Patent
[Serial No] 0003083 (or JPAP No. 2001-002258)
[Date of filing] January 10, 2001 (or 13th in Heisei)
[Addressee] Director-General of the Patent Office
[Int. Cl.] G11B 7/24
[Title of the Invention]
OPTICAL RECORDING MEDIUM AND SPUTTERING TARGET
[Number of claims] 11

[Inventor]
[Address] c/o Kabushiki Kaisha Ricoh
3-6 Nakamagome, 1-chome, Ohta-ku, Tokyo
[Name] Nakamura (family) Yuki (first)

[Inventor]
[Address] c/o Kabushiki Kaisha Ricoh
3-6 Nakamagome, 1-chome, Ohta-ku, Tokyo
[Name] Masaki Katoh

[Applicant]
[ID No] 000006747
[Name] Kabushiki Kaisha Ricoh
[Representative] Masamitsu Sakurai
[Application fee]

[Prepayment No]	003724
[Amount of payment]	21000 Yen
[List of documents attached]	
[Name of document]	Specification 1
[Name of document]	Drawings 1
[Name of document]	Abstract 1
[Proof reading]	Required

[Name of Document] Specification

[Title of the Invention]

OPTICAL RECORDING MEDIUM AND SPUTTERING TARGET

[What is claimed is:]

[Claim 1]

An optical recording medium comprising a recording layer containing at least materials capable of carrying out read/write/erase operations through phase changes of said materials therein, which is characterized by said recording layer essentially consisting of Ag, In, Sb and Te, with a proportion in atomic percent of a(Ag): b(In): c(Sb): d(Te), with $0.1 \leq a \leq 7$, $2 \leq b \leq 10$, $64 \leq c \leq 92$ and $5 \leq d \leq 26$, provided that $a + b + c + d \geq 97$.

[Claim 2]

An optical recording medium comprising a recording layer containing at least materials capable of carrying out read/write/erase operations through phase changes of said materials therein, which is characterized by said recording layer essentially consisting of Ag, In, Sb, Te and Ge, with a proportion in atomic percent of a(Ag): b(In): c(Sb): d(Te): e(Ge), with $0.1 \leq a \leq 7$, $2 \leq b \leq 10$, $64 \leq c \leq 92$, $5 \leq d \leq 26$ and $0.3 \leq e \leq 3$, provided that $a + b + c + d + e \geq 97$.

[Claim 3]

An optical recording medium comprising a substrate, and contiguous layers formed on said substrate in order as follows, a first dielectric layer, a recording layer, a second dielectric layer,

a metal/alloy layer, and an ultraviolet light curing resinous layer, which is characterized by said recording layer essentially consisting of phase change recording materials having a composition as claimed in anyone of claims 1 and 2.

[Claim 4]

The optical recording medium according to claim 3, which is characterized by said first dielectric layer, recording layer, second dielectric layer and metal/alloy layer each formed having a thickness ranging from 30 nm to 220 nm, 10 nm to 25 nm, 10 nm to 50 nm, and 70 nm to 250 nm, respectively.

[Claim 5]

The optical recording medium according to claim 3, which is characterized for said recording medium to be rewritable at least once at a linear recording velocity ranging from 9 m/sec to 30 m/sec.

[Claim 6]

The optical recording medium according to anyone of claims 1 and 2, which is characterized by said recording layer having a composition satisfying a relation of $88 \leq c + d \leq 98$.

[Claim 7]

The optical recording medium according to claim 4, which is characterized by said metal layer essentially consisting of Al and at least one kind of additive with a content ranging from 0.3 weight percent to 2.5 weight percent, said additive being selected from the group consisting of Ta, Ti, Cr and Si.

[Claim 8]

The optical recording medium according to claim 4, which is characterized by said metal/alloy layer essentially consisting

of Ag and at least one kind of additive with a content ranging from 0 to 4 weight percent, said additive being selected from the group consisting of Au, Pt, Pd, Ru, Ti and Cu.

[Claim 9]

A sputtering target for forming a recording layer, said recording layer being incorporated into an optical recording medium capable of carrying out read/write/erase operations through phase changes of materials therein, in which said sputtering target is characterized by essentially consisting of Ag, In, Sb and Te, with a proportion in atomic percent of a(Ag): b(In): c(Sb): d(Te), with $0.1 \leq a \leq 7$, $2 \leq b \leq 10$, $64 \leq c \leq 92$ and $5 \leq d \leq 26$, provided that $a + b + c + d \geq 97$.

[Claim 10]

A sputtering target for forming a recording layer, said recording layer being incorporated into an optical recording medium capable of carrying out read/write/erase operations through phase changes of materials therein, in which said sputtering target is characterized by essentially consisting of Ag, In, Sb, Te and Ge, with a proportion in atomic percent of a(Ag): b(In): c(Sb): d(Te): e(Ge), with $0.1 \leq a \leq 7$, $2 \leq b \leq 10$, $64 \leq c \leq 92$, $5 \leq d \leq 26$ and $0.3 \leq e \leq 3$, provided that $a + b + c + d + e \geq 97$.

[Claim 11]

The sputtering target according to anyone of claims 9 and 10, which is characterized by having a composition satisfying the relation $88 \leq c + d \leq 98$.

[Detailed Description of the Invention]

[0001]

[Technical field of the Invention]

This patent specification relates to an optical recording medium in general and, more particularly, to a phase-change recording medium including a recording material capable of causing the phase changes by irradiating light beam to the material, thereby implementing recording, reproducing and rewriting operations of information data, which is utilized in optical memory devices such as, in particular, rewritable compact disks (CDs).

This patent specification also relates a sputtering target and methods for forming such target, which are suitably utilized for forming the recording material capable of causing the phase changes by irradiating light beam to the material, thereby implementing recording, reproducing and rewriting operations of information data.

[0002]

[Background Art]

Of the optical storage devices, a phase-change recording medium is now well known being capable of implementing repeated read/ write/ erase operations by means of laser beam irradiation utilizing the phase transition of either crystalline-crystalline, or crystalline-amorphous states.

For this type of the recording media in particular, overwrite operations can be carried out using a single light beam and a relatively simple optical system for readout steps, which is advantageous over the magneto-optical memories that has

difficulties in overwriting. The phase-change recording medium has therefore been attracting increasing research and development activities recently.

As a typical example, U.S. Patent No. 3,530,441 discloses chalcogenide alloys such as Ge-Te, Ge-Te-Sn, Ge-Te-S, Ge-Se-S, Ge-Se-Sb, Ge-As-Se, In-Te, Se-Te and SeAs.

Also disclosed to improve stability and crystallization speed are Ge-Te alloy materials added with Au (Japanese Laid-Open Patent Application No. 61-219692), with Sn and Au (Japanese Laid-Open Patent Application No. 61-270190), or with Pd (Japanese Laid-Open Patent Application No. 62-19490). Further disclosed to improve write/readout characteristics for repeated operations are Ge-Te-Se-Sb and Ge-Te-Sb alloys with specified compositions (Japanese Laid-Open Patent Applications No. 62-73438 and 63-228433).

[0003]

These alloy materials, however, have not been satisfactory in achieving various characteristics of the rewritable phase-change optical recording medium.

In particular, there remain several problems of great importance yet to be solved to achieve desirable characteristics. The problems may be achieved by attaining sufficient sensitivity during either writing or erasing operation, preventing the decrease in erasure ratio caused by leftover portions during overwriting steps, and improving the durability of the media properties of either written or non-written portions in the recording medium.

[0004]

Another recording medium is proposed in Japanese Laid-Open Patent Application No. 63-251290, including a single recording layer with a crystallized state of practically more than ternary composition. By "practically more than ternary" is meant in the disclosure that the alloy system includes at least 90 atomic % of a ternary compound (e.g., In_3SbTe_2) in the recording layer. It is also stated in the disclosure that write/erasure characteristics are improved with this alloy composition. However, the composition still has shortcomings such as erasure ratio of relatively small magnitude and laser power to be reduced for write/erase operations.

[0005]

In addition, still another recording medium is proposed in Japanese Laid-Open Patent Application No. 1-277338, including $(Sb_a Te_{1-a})_{1-y} M_y$ with $0.4 \leq a \leq 0.7$ and $y \leq 0.2$, in which M includes at least one additive selected from the group consisting Ag, Al, As, Au, Bi, Cu, Ga, Ge, In, Pb, Pt, Se, Si, Sn and Zn.

This alloy system essentially consists of Sb_2Te_3, and several medium characteristics with this system is described to have been improved in several characteristics such as high speed write/erase cycle operations by including a rather excess amount of Sb, and high speed erasure by the addition of M elements. In addition, it is also stated that the erasing ratio is obtained to be relatively large for light beams in the continuous (or DC) mode. However, no description is found in the disclosure with respect to the erasing ratio during overwrite operations.

In this context, it may be noted that erasure leftover portions have been found by the present inventors during erasing

experiment on the alloy system, and its recording sensitivity is considered not satisfactory.

[0006]

In a similar manner, further recording media are proposed including respective recording layers such as one disclosed in Japanese Laid-Open Patent Application No. 60-177446 including $(In_{1-x}Sb_x)_{1-y}M_y$ with $0.55 \leq x \leq 0.80$ and $0 \leq y \leq 0.20$, where M includes at least one kind of element selected from the group consisting Au, Ag, Cu, Pd, Pt, Al, Si, Ge, Ga, Sn, Te, Se and Bi; the other disclosed in Japanese Laid-Open Patent Application No. 63-228433 including an alloy $GeTe$-Sb_2Te_3-Sb(in excess). However, the recording media composed of these alloy systems have not attained sufficient media characteristics such as the recording sensitivity and erasing ratio.

[0007]

Further, there disclosed are optical recording media provided with respective recording layers including alloy systems such as, a Ge-Te-Sb alloy added with N, described in Japanese Laid-Open Patent Application No. 4-163839; a Te-Ge-Se alloy formed such that at least one of constituent elements thereof is incorporated as a nitride, described in Japanese Laid-Open Patent Application No. 4-52188; and a Te-Ge-Se alloy adsorbed with N, described in Japanese Laid-Open Patent Application No. 4-52189. The optical recording media composed of these alloy systems, however, have not acquired satisfactory characteristics for the recording media.

[0008]

In spite of numerous alloy materials for forming recording

layers of the optical recording media, as described hereinabove, there persist needs to solve several problems of great importance and to thereby acquire desirable media characteristics such as sufficient sensitivity during either writing or erasing operation by preventing the decrease in erasure ratio caused by leftover portions during overwrite steps, also improving durability of the structure and property of recorded and non-recorded portions in the recording medium.

[0009]

As to the optical media, compact discs (CDs) have come into wide use recently as viable information storage media. Along with the rapid growth of the CDs, another type of compact discs, which are writable only once discs (or CD-R's) have been developed and recently placed into the market. However, since information data once recorded on the CD-R disc cannot be corrected because of its write-once feature mentioned just above, the CD-R disc has a shortcoming, in that the disc has to be abandoned when even one non-correctable error is inputted during the writing steps. Another type of the storage medium has therefore been awaited for, that is capable of obviating the above disadvantage of the CD-R disc.

As an example of such storage media, there may be cited is a rewritable compact disc which incorporates magneto-optical materials. The magneto-optical disc, however, has drawbacks such as difficulty in overwriting and being incompatible with CD-ROM and CD-R discs. Therefore, a phase-change type recording medium has been actively developed recently toward practical use as one which features disc characteristics favorable

to compatibility with the above media, among others.

[0010]

The research and development results disclosed so far are exemplified on the rewritable phase-change recording media and compact discs incorporating the recording media by Furuya, et al., Proceedings of the 4th Symposium on phase change optical recording (1992) 70; Kanno, et al., Proceedings of the 4th Symposium on phase change optical recording (1992) 76; Kawanishi, et al., Proceedings of the 4th Symposium on phase change optical recording (1992) 82; Handa, et al., Japanese Journal of Applied Physics, Vol. 32 (1993) 5226; Yoneda, et al., Proceedings of the 5th Symposium on phase change optical recording (1993) 9; and Tominaga, et al., Proceedings of the 5th Symposium on phase change optical recording (1993) 5.

These rewritable phase-change recording media, however, have not satisfied overall characteristics, such as the compatibility with CD-ROMs and CD-Rs, write/ erase capability, recording sensitivity, repeatability of rewriting and readout operations, and durability during storage. The above noted shortcomings in the media characteristics are considered primarily due to relatively low erasure ratios which are caused by the composition and/ or structure of previously recording materials employed for forming the phase-change recording media.

[0011]

Accordingly, it is desirable to develop novel recording materials capable of attaining higher erasure ratios and being suitable for more sensitive write/erase operations, to thereby be

able to implement phase-change compact discs having improved rewritable capabilities.

In order to find such improved material systems and thereby solve the above noted shortcomings, the present inventors have previously proposed several AgInSbTe recording materials. These materials are disclosed in Japanese Laid-Open Patent Applications No. 3-240590, 4-78031, 4-123551, 4-232779, 5-345478 and 8-22644.

These mixed alloy systems have been found with excellent sensitivity during either writing or erasing operation, and particularly with large erasure ratios, thereby being advantageous to forming recording layers utilizing the mark-edge recording method.

However, since the AgInSbTe mixed alloy systems have been developed to this date for use in recording media primarily with linear recording speed of 10 m/sec or less, the recording media incorporating these alloy system have drawbacks such as insufficient recording cycle capability for the practical use as the recording media with the recording speed of 10 m/sec or larger.

[0012]

[Problems to be solved by the Invention]

It is the first object of present disclosure, according to the abovementioned current status of the characteristics of the recording medium, to provide an optical recording medium suitably optimized for implementing recording and erasing operations at a linear recording velocity ranging from 9 m/sec to 30 m/sec.

[0013]

It is the second object of present disclosure to provide a phase-change recording medium suitable for use in compact discs having high speed rewriting capabilities.

[0014]

It is the third object of present disclosure to provide a sputtering target suitably used for realizing the abovementioned first and second objects.

[0015]

[Means for Solving the Problems]

After rigorous research efforts for improving the phase-change recording medium, the present inventors have found phase-change recording media and a sputtering target suitably used for forming the recording media, to thereby be able to acquire the findings included in the present disclosure.

Namely, there described in this disclosure are;

[0016]

first, in an optical recording medium comprising a recording layer containing at least materials capable of carrying out recording and erasing operations through phase changes of the materials included therein, the recording layer characterized by essentially consisting of Ag, In, Sb and Te, with a proportion in atomic percent of a(Ag): b(In): c(Sb): d(Te), with $0.1 \leq a \leq 7$, $2 \leq b \leq 10$, $64 \leq c \leq 92$ and $5 \leq d \leq 26$, provided that $a + b + c + d \geq 97$;

[0017]

second, in an optical recording medium comprising a recording

layer containing at least materials capable of carrying out recording and erasing operations through phase changes of the materials included therein, the recording layer characterized by essentially consisting of Ag, In, Sb, Te and Ge, with a proportion in atomic percent of a(Ag): b(In): c(Sb): d(Te): e(Ge), with $0.1 \leq a \leq 7$, $2 \leq b \leq 10$, $64 \leq c \leq 92$, $5 \leq d \leq 26$ and $0.3 \leq e \leq 3$, provided that $a + b + c + d + e \geq 97$;

[0018]

third, in an optical recording medium comprising a substrate, and contiguous layers formed on the substrate in order as follows, a first dielectric layer, a recording layer, a second dielectric layer, a metal/ alloy layer, and an ultraviolet light curing resinous layer, the recording layer characterized by essentially consisting of phase change recording materials having the composition indicated in either (1) or (2) above;

[0019]

fourth, in the optical recording medium indicated in (3), the first dielectric layer, recording layer, second dielectric layer and metal/alloy layer each characterized by having a thickness ranging from 30 nm to 220 nm, 10 nm to 25 nm, 10 nm to 50 nm, and 70 nm to 250 nm, respectively;

[0020]

fifth, in the optical recording medium indicated in (4), the recording medium characterized by its rewritable capabilities at least once at a linear recording velocity ranging from 9 m/sec to 30 m/sec;

[0021]

sixth, in the optical recording medium indicated in either (1) or

(2), the recording layer characterized by having a composition satisfying the relation of $88 \leq c + d \leq 98$;

[0022]

seventh, in the optical recording medium indicated in (4), the metal layer characterized by essentially consisting of Al and at least one kind of additive with a content ranging from 0.3 weight percent to 2.5 weight percent, the additive being selected from the group consisting of Ta, Ti, Cr and Si;

[0023]

eighth, in the optical recording medium indicated in (4), the metal/alloy layer characterized by essentially consisting of Ag and at least one kind of additive with a content ranging from 0 to 4 weight percent, the additive being selected from the group consisting of Au, Pt, Pd, Ru, Ti and Cu;

[0024]

ninth, a sputtering target, for forming a recording layer included in an optical recording medium capable of carrying out recording and erasing operations through phase changes of the materials in the recording layer, characterized by essentially consisting of Ag, In, Sb and Te, with a proportion in atomic percent of a(Ag): b(In): c(Sb): d(Te), with $0.1 \leq a \leq 7$, $2 \leq b \leq 10$, $64 \leq c \leq 92$ and $5 \leq d \leq 26$, provided that $a + b + c + d \geq 97$;

[0025]

tenth, a sputtering target, for forming a recording layer included in an optical recording medium capable of carrying out recording and erasing operations through phase changes of the materials in the recording layer, characterized by essentially

consisting of Ag, In, Sb, Te and Ge, with a proportion in atomic percent of a(Ag): b(In): c(Sb): d(Te): e(Ge), with $0.1 \leq a \leq 7$, $2 \leq b \leq 10$, $64 \leq c \leq 92$, $5 \leq d \leq 26$ and $0.3 \leq e \leq 3$, provided that $a + b + c + d + e \geq 97$; and

[0026]

eleventh, the sputtering target indicated in either (9) or (10), characterized by having a composition satisfying a relation of $88 \leq c + d \leq 98$.

[0027]

[DESCRIPTION OF THE PREFERRED EMBODIMENTS]

Preferred embodiments will be detailed herein below.

The recording medium disclosed herein is characterized by quaternary phase-change recording materials including compositional elements such as Ag, In, Sb and Te, as the major components. The recording materials are found having several characteristics suitable for use in optical recording media, such as excellent sensitivity to, and speed of, recording (i.e., amorphous phase formation) and erasure (crystalline phase formation), and also having desirable erasure ratios.

The phase-change recording materials preferably have the composition described earlier either in (1) or (2), in inclusive of an additional compositional relation of (6) to attain recording media characteristics improved further.

[0028]

The results on the composition of the recording layers disclosed herein have been obtained from the emission spectral analysis, while other methods may also be used for the analysis,

such as X-ray microanalysis, Rutherford backscattering, Auger analysis, fluorescent X-ray spectroscopy and other similar methods. The results obtained from the latter methods may be used to compare with those from the emission spectral analysis. For the emission spectral analysis, its error of measurements is known in general to be within 5%.

The structure of the materials in the recording layer may be examined by the diffraction method using either X-rays or electron beams. The crystalline state, for example, can be distinguished from the amorphous state using the electron beam diffraction method, in which the presence of diffraction spots and/or Debye rings in diffraction patterns is generally taken to be indicative of the crystalline state, while halo rings are of the amorphous state. In addition, the diameter of the crystallites may be calculated from the peak width at half maximum of the X-ray diffraction patterns according to the Scherrer's equation.

[0029]

The nature of chemical bonds of oxides and nitrides included in the recording layer may be analyzed by spectroscopic methods such as, for example, FT-IR and XPS.

Recording layers are formed by sputtering methods using sputtering targets disclosed herein, preferably having a thickness ranging from 10 to 50 nm, more preferably from 12 to 25 nm. The layer thickness less than 10 nm causes considerable decreases in absorbency and become incapable of functioning as proper recording layers, while difficulties in achieving uniform phase transition result for the thickness larger than 50 nm at high speed recording.

[0030]

It is known a recording layer suitable for the optical data recording can be formed using a sputtering target, in which two components are included, one SeTe alloy and the other $AgInTe_2$ alloy having a composition of at least in the vicinity of the stoichiometric composition of either chalcopyrite or zincblende. The thus formed recording layer is subsequently subjected to appropriate layer processing such as, for example, initialization steps, whereby a recording layer is completed with desirable recording characteristics such as large erasure ratios and repeated write/ erase capabilities.

[0031]

The crystallite size of the above mentioned $AgInTe_2$ alloy, which has a structure of at least in the vicinity of either chalcopyrite or zincblende structure, can be determined by the X-ray diffraction method. That is, from the peak width at half maximum obtained for the main peak in X-ray diffraction (at diffraction angle of 24.1° for CuKα X-rays having $\lambda = 1.54$A), the crystallites size can be calculated. It is desirable to calibrate in advance using a well defined standard set of the crystallite size to ascertain the accuracy of the determination.

For the $AgInTe_2$ alloy with the crystallite size exceeding 45 nm, stable record/erase operations becomes difficult even after proper initialization process on the recording layer.

[0032]

In addition, by using Ar sputtering gaseous compositions which include an adjusted amount of N gas of at most 10 mol%, desirable properties of the recording layer can be obtained

depending on the N composition, so as to attain appropriate disc characteristics such as linear velocity of rotation and disc layer structure.

The use of the above noted mixed Ar/ N gaseous compositions can also yield improved durability in record/ erasure operations. The Ar/ N gaseous compositions may be prepared either by mixing gaseous constituents in a predetermined mixing ratio prior to the introduction into a sputtering chamber, or by adjusting the proportion of respective incoming gaseous constituents such that a predetermined molar ratio be attained inside the sputtering chamber following the introduction.

[0033]

The amount of N in the recording layer is preferably at most 5 atomic % to achieve appropriate disc characteristics. In addition to the above noted overwrite (O/ W) characteristics in repeated operations, concrete examples of improved disc characteristics are found on percentage modulation and storage life for the recorded marks (or amorphous marks), among others.

Although the details are yet to be clarified, the mechanism for these effects is considered as follows: The incorporation of N into the recording layer tends to increase the coarseness of the film structure caused by the decrease in layer density and by the increase in minute defects. As a result, the structural order of the layer is more relaxed than that prior to the N incorporation, which, in turn, tends to suppress the transition from the amorphous state to the crystalline state, and the stability of amorphous marks increases, thereby improving the storage life

for the recorded marks. Furthermore, the linear velocity of the transition is also controlled suitably by adding appropriate amount of N into the recording layer.

[0034]

To be more specific, the phase-change linear velocity, or optimum linear recording velocity, can be decreased by adding appropriate amount of N. As a result, the phase-change linear velocity can be suitably adjusted by appropriately controlling N2/Ar gaseous compositions even for the recording layers formed from the same sputtering target.

[0035]

The N elements are preferably incorporated into the recording layer chemically bonded to at least one of Ag, In, Sb and Te elements. When the chemical bond is formed with Te, in particular, such as exemplified by Te-N and Sb-Te-N, pronounced effects can be achieved with the improvement in the number of repeated overwrite cycles.

Such chemical bonds may be analyzed by spectroscopic methods such as, for example, FT-IR and XPS. In FT-IR spectra, for example, the Te-N bond exhibits an absorption peak in the 500-600 cm^{-1} spectral range, while the Sb-Te-N bond has an absorption peak in the 600-650 cm^{-1} range.

[0036]

In addition, it is effective for the recording layer to incorporate other elements or impurities to further improve media characteristics. For example, these additives are preferably selected from the group consisting of B, N, C, P and Si, as disclosed in Japanese Laid-Open Patent Application No.

4-1488, and another group consisting of O, S, Se, Al, Ti, V, Mn, Fe, Co, Ni, Cu, Zn, Ga, Ge, Sn, Pd, Pt and Au. The addition of Ge elements is particularly effective in improving the durability of recorded marks and the number of O/W cycles.

[0037]

The thus formed recording layer is subsequently incorporated into an optical recording medium which will be described herein below in reference to FIG. 1.

A phase-change optical recording medium disclosed herein preferably includes a supporting substrate 1, and the following layers formed contiguously on the supporting substrate in order as follows: A first dielectric (heat resisting, protective) layer 2, a recording layer 3, a second dielectric (heat resisting, protective) layer 4, and a reflective/ (heat dissipating) layer 5.

Although both first and second dielectric layers 2,4 need not be formed placing the recording layer 3 there between as shown in FIG. 1, the formation of the former layer 2 is preferred in case of the substrate 2 formed of relatively low melting point materials such as polycarbonate, for example.

[0038]

The supporting substrate 1 is formed of materials preferably enough transparent to light in the wavelength range for use in recording and readout operations of the recording medium.

Suitable materials for forming the substrate 1 include glass, ceramics and resinous materials. Of these materials, resins are preferably employed for its satisfactory transparency and moldability.

Specific examples of the resins include polycarbonate resins, acrylic resins, epoxy resins, polystyrene resins, acrylonitrile-styrene copolymeric resins, polyethylene resins, polypropylene resins, silicone resins, fluororesins, acrylonitrile-butadiene-styrene (ABS) resins and urethane resins. Among these resins, polycarbonate resins and acrylic resins are preferably used for their excellent moldability, optical properties and relatively low costs.

While the substrate 1 is usually of disc-shaped, it may also be of card or sheet-shaped.

[0039]

In addition, the substrate may be provided with grooves, in general, and the grooves are formed preferably under the following conditions in case for use in rewritable compact disc (CD-Rewritable). That is, the grooves formed to help guide the laser beams during the read/write operations preferably have a width ranging from 0.35 μm to 0.70 μm, more preferably from 0.45 μm to 0.65 μm; a depth thereof ranging from 15 nm to 60 nm, more preferably from 20 nm to 50 nm.

By implementing these substrate conditions together with the recording material and medium construction described earlier, a rewritable compact disc can be formed with excellent compatibility.

To be more specific, the magnitude of push-pull signals after recording, PPm, is proposed as one of important characteristic values for the compact disc (according to CD Standards), in which PPm values are required to be in the range between 0.04 and 0.15, preferably between 0.06 and 0.14, and

most preferably between 0.08 and 0.12.

It has been quite difficult for phase change rewritable compact discs to satisfy these PPm conditions and all other major requirements for read/write characteristics simultaneously at the linear recording speed of 10 m/sec or greater. However, this becomes feasible with the advent of the phase change recording media disclosed herein, fulfilling the overall characteristics required for the practical rewritable compact discs.

[0040]

The dielectric (heat resisting, protective) layers are formed primarily consisting of dielectric materials for their suitable thermal and optical properties.

Examples of suitable dielectric materials for forming the dielectric layers include metal oxides such as SiO, SiO_2, ZnO, SnO_2, Al_2O_3, TiO_2, In_2O_3, MgO and ZrO_2; nitrides such as Si_3N_4, AlN, TiN, BN and ZrN; sulfides such as ZnS, In_2S_3 and TaS_4; carbides such as SiC, TaC, B_4C, WC, TiC and ZrC; diamond-like carbon, and mixtures thereof.

These materials may be used individually or in combination. In addition, they may further include impurities, where relevant. While the dielectric layers may be formed to have a multilayered structure, their melting temperatures are preferably higher than that of the recording layer.

The first and second dielectric layers 2,4 can be formed by, for example, vacuum evaporation, sputtering, plasma CVD, light assisted CVD, ion plating, or electron beam evaporation, or other similar methods.

[0041]

The materials and thickness for forming respective dielectric layers may be determined independent one another after considering optical and thermal properties.

The first dielectric layer 2 preferably has a thickness ranging from 20 nm to 200 nm, more preferably from 30 nm to 120 nm. When the thickness thereof is smaller than 20 nm, the layer cannot serve as a heat resisting protective layer, while the thickness of larger 200 nm causes several difficulties such as peeling-off at interlayer portions with relative ease and reducing the recording sensitivity.

The thickness of the second dielectric layer 4 preferably ranges from 15 nm to 40 nm, more preferably from 20 nm to 35 nm. When the thickness thereof is smaller than 15 nm, the layer cannot serve as a heat resisting protective layer and result the decrease in recording sensitivity. In contrast, the thickness of larger 40 nm causes again several difficulties such as peeling-off at interlayer portions with relative ease and reducing the recording sensitivity in repeated recording operations.

In addition, the dielectric layers 2,4 may be formed to have a multilayered structure, as indicated earlier.

[0042]

Subsequently, the reflective (heat dissipating) layer 5 is formed on top of the second dielectric (heat resisting, protective) layer 4.

Suitable materials for forming the reflective layer 5 include metals such as Al, Au, Ag and Cu and alloys thereof. Of these materials, Al alloys, Ag metal, and its alloys are preferably employed for its excellent durability and low costs. These

metals and alloys may each be added with impurities, in which Ta, Ti, Cr and Si elements are effective for the Al alloys, while Au, Pt, Pd, Ru, Ti and Cu are suitable for the Ag alloys.

The reflective layer 5 can be formed by, for example, vacuum evaporation, sputtering, plasma CVD, light assisted CVD, ion plating, electron beam evaporation, or other similar methods. In order for the reflective layer 5 to properly serve as a heat dissipating layer, the thickness thereof is preferably ranging from 50 nm to 200 nm, more preferably from 70 nm to 180 nm.

The thickness thereof larger than that above noted cause an excessive heat dissipation to result in the decrease in recording sensitivity, while decrease in the overwrite cycle characteristics is found except recording sensitivity retained for smaller layer thickness.

As suitable properties for the reflective layer material, therefore, high heat conductivity, high melting point, and also sufficient adhesion are preferable.

[0043]

As electromagnetic radiation and energetic beams useful for initializing, recording, reading-out, or erasing the recording medium disclosed herein, laser light, ultraviolet light, visible light, infrared light or microwave radiation may be utilized. Of these radiation and beams, light beams from a semiconductor laser device are preferably used for its smallness in size and compactness, thereby being suitably incorporated into a drive unit for operating the recording media.

[0044]

[EXAMPLES]

The following examples are provided further to illustrate preferred embodiments of the present invention. This is intended to be illustrative but not to be limiting to the materials, apparatuses or methods described herein.

[0045]

EXAMPLES 1 through 10, and

COMPARATIVE EXAMPLES 1 through 5

A plurality of phase-change recording media was formed, using sputtering targets, including constituent layers, which will be detailed herein below.

The materials composition of sputtering targets used for the layer deposition and the composition of the layers formed by the deposition together with their O/W characteristics are given in respective columns in Table 1.

A phase-change recording medium was first fabricated on a polycarbonate (PC) substrate of 1.2 mm thickness, which was provided with guide tracks of a track pitch of 1.6 μm formed wit grooves having a depth of approximately 30 nm and a width of approximately 0.6 μm.

The following constituent layers were subsequently formed on the PC substrate in order as follows by sputtering deposition technique using respective sputtering targets: A first dielectric layer of $SiO_2 \cdot ZnS$ with a thickness of approximately 80 nm, a recording layer of approximately 18 nm thickness, a second dielectric layer of $SiO_2 \cdot ZnS$ with a thickness of approximately 32 nm, a reflective/ heat dissipating layer of Al alloy containing 1.5 wt % of Ti with a thickness of approximately 160 nm, and a

coated layer of UV curing resin with a thickness of approximately 10 μm, whereby a recording medium was formed.

The sputtering deposition of the recording layer was carried out in Ar gas flow of 10 sccm under 3×10^{-3} Torr pressure with RF power of 500 W.

[0046]

The thus formed recording media were then subjected to data recording process and characteristic measurements. During the measurements, linear velocities for the data recording suitable for respective recording media were selected ranging from 9 m/sec to 30 m/sec.

As to the signal recording, the EFM method was utilized irradiating with multi-pulsed laser beams during recording. The optical pickup unit presently used had an objective lens of an aperture of NA 0.5 and a semiconductor laser with the emission of 780 nm in wavelength.

Results obtained from the measurements are shown in Table 1 on the reflectivity and the number of overwrite cycles for respective recording media. It is added the mark '×' in the overwrite cycle column indicates that an overwriting could not be achieved even though the first recording was feasible.

[0047]

From the results in Table 1, it is indicated excellent disc characteristics are obtained for recording layer compositions of a: b: c: d: e, with $0.1 \leq a \leq 7$, $2 \leq b \leq 10$, $64 \leq c \leq 92$, $5 \leq d \leq 26$ and $0.3 \leq e \leq 3$, where a, b, c, d and e are the content (atom %) of Ag In, Sb, Te and Ge, respectively.

It is also indicated from the results in Comparative

Examples 3 and 5 that the reflectivity value was obtained to be 14% or less, for the content, Sb + Te, of 88 atom % or smaller, whereby the readout compatibility with CD-ROM drive was decreased and repetitive recording cycle capability was deteriorated.

In addition, for the content, Sb + Te, of 93 atm % or larger, as in Comparative Example 2, the reflectivity becomes too high, whereby readout errors increased since signal amplitudes of sufficiently large magnitude could not be obtained.

Further, on the recording medium with the content as in Comparative Examples 4, 6 and 7, the media overwrite could not be achieved at the linear recording velocity of 9 m/sec.

It may be added herein that the sputtering targets used for forming the above recording layers of Examples 1 through 10 and Comparative Examples 1 through 5, were prepared respectively first by melting raw constituent materials, then cooling to be solidified, crushing or milling, and subsequently sintering.

[0048]

Table 1-1

	Sputtering Target Composition				
	Ag	In	Sb	Te	Ge
Example 1	1.0	9.0	66.0	24.0	0.0
Ex. 2	2.0	7.0	77.0	14.0	0.0
Ex. 3	7.0	4.5	68.5	20.0	0.0
Ex. 4	0.5	5.5	81.5	12.5	0.0

Ex. 5	0.5	2.5	92.0	5.0	0.0
Ex. 6	1.5	9.0	67.5	22.0	0.0
Ex. 7	1.0	6.5	74.5	18.0	0.0
Ex. 8	1.0	7.0	70.0	21.0	1.0
Ex. 9	0.5	7.5	65.0	25.0	2.0
Ex. 10	3.0	5.0	65.0	24.0	3.0
Comparative Example 1	7.0	6.0	63.0	24.0	0.0
Com. Ex. 2	2.0	1.0	93.0	4.0	0.0
Com. Ex. 3	3.0	11.0	66.0	20.0	0.0
Com. Ex. 4	1.0	7.5	63.5	28.0	0.0
Com. Ex. 5	1.0	7.6	63.0	22.5	6.0
Com. Ex. 6	4.5	5.5	62.5	27.5	0.0
Com. Ex. 7	5.5	4.0	63.0	26.5	1.0

Table 1-2

	Layer Composition					Characteristics	
	Ag	In	Sb	Te	Ge	Reflect-ivity (%)	O/W cycles
Example 1	0.9	9.1	66.2	23.8	0.0	16	8000
Ex. 2	2.1	6.9	77.1	13.9	0.0	17	5000
Ex. 3	7.1	4.6	68.4	19.9	0.0	15	3000

Ex. 4	0.6	5.5	81.6	12.5	0.0	20	4000
Ex. 5	0.6	2.4	92.1	4.9	0.0	22	5000
Ex. 6	1.5	9.1	67.6	21.8	0.0	15	8000
Ex. 7	1.1	6.6	74.4	17.9	0.0	18	6000
Ex. 8	0.9	7.1	70.0	20.1	0.9	17	4000
Ex. 9	0.6	7.6	64.9	24.9	2.0	16	6000
Ex. 10	3.1	4.9	64.8	24.1	3.1	15	7000
Comparative Example 1	6.9	6.1	62.9	24.1	0.0	13	300
Com. Ex. 2	2.0	1.1	92.9	4.0	0.0	22	500
Com. Ex. 3	2.9	11.2	66.1	19.8	0.0	12	600
Com. Ex. 4	1.1	7.4	63.4	28.1	0.0	17	×
Com. Ex. 5	1.0	7.6	63.0	22.4	6.0	13	200
Com. Ex. 6	4.4	5.6	62.4	27.6	0.0	16	×
Com. Ex. 7	5.4	4.1	62.9	26.6	1.0	15	×

[0049]

EXAMPLE 11

Several phase-change recording media were formed each including recording layers which were deposited using the sputtering target of Example 1. In addition, the sputtering deposition of respective recording layers was carried out in Ar gas atmosphere mixed with 0, 6, 10 or 15 mol % of gaseous nitrogen.

The composition of the thus formed recording layers was subsequently obtained. In addition, the recording layers were each incorporated into recording media and the overwrite characteristics of these media were also measured. The results from these measurements on the recording layer composition and overwrite cycle number are shown in Table 2.

[0050]

Table 2

N2/(Ar+N2) (mol %)	Content (atom %)					O/W cycles
	Ag	In	Sb	Te	N	
0	2.1	6.9	77.1	23.9	0	5000
6.0	1.7	6.6	76.3	23.4	2.0	4000
10.0	1.5	6.4	75.2	22.9	4.0	800
15.0	1.4	6.3	74.7	22.6	5.0	200

It is clearly shown from the results included in Table 2 that the number feasible of O/W cycles sharply decreases in nitrogen contents in excess of 10 mol %.

[0051]

<u>EXAMPLES 12 through 23, and</u>
<u>COMPARATIVE EXAMPLES 8 through 11</u>

Several phase-change recording media were formed using the sputtering target of Example 1 in a similar manner to

Examples 1 through 10 and Comparative Examples 1 through 5.

The recording media each include the following layers deposited on a polycarbonate substrate of 1.2 millimeter thickness, such as a first dielectric layer of $SiO_2 \cdot ZnS$ with a thickness of approximately 90 nm, a recording layer of approximately 18 nm thickness, a second dielectric layer of $SiO_2 \cdot ZnS$ with a thickness of approximately 34 nm, and a reflective/ heat dissipating layer of approximately 160 nm thickness. The reflective/ heat dissipating layers for forming respective recording media were each formed herein with metal or alloy layers having the composition shown in respective columns in Table 3.

When the thus formed recording media were subsequently subjected to the measurements on reflectivity, overwrite cycle number and storage durability, the results were obtained as shown in Table 3. For the storage durability, the measurements were made at 80 °C and relative humidity of 85%, and the mark '×' in Table 3 indicates that the increase in errors was found after 300 hours in storage.

[0052]

Table 3

	Reflective layer (atom %)	Reflect-ivity (%)	O/W cycles	Storage durability
Ex. 12	Al99.5Ti0.5	19	2000	○
Ex. 13	Al97.5Ti2.5	17	3000	○

Ex. 14	Al98.5Ta1.5	18	3000	○
Ex. 15	Al98.5Cr1.5	17	2500	○
Ex. 16	Al98.5Si1.5	19	1500	○
Ex. 17	Al98.5Ti1.0Ta0.5	18	3000	○
Ex. 18	Ag100	20	3000	○
Ex. 19	Ag98Pd2	18	4000	○
Ex. 20	Ag98Cu2	19	3000	○
Ex. 21	Ag98Au2	19	5000	○
Ex. 22	Ag98Pt2	19	4000	○
Ex. 23	Ag96Pd2Cu2	17	3000	○
Ex. 24	Ag98Ru2	18	4000	○
Ex. 25	Ag98Ti2	19	5000	○
Com. Ex. 8	Al95Ti5	14	200	○
Com. Ex. 9	Al99Mg1	18	100	×
Com. Ex. 10	Al98.5Cu1.5	14	300	×
Com. Ex. 11	Ag94Pd6	13	200	○

It is shown from the results included in Table 3 that (1) reflective/ heat dissipating layers each essentially consisting of Al yield satisfactory media characteristics, when at least one kind of element selected from the group consisting of Ta, Ti, Cr and Si is included therein with its content ranging between 0.3 to 2.5 wt %, and (2) the metal or alloy layers as reflective/ heat

dissipating layer each essentially consisting of Ag exhibit excellent overwrite characteristics and storage durability, when at least one kind of element selected from the group consisting of Au, Pt, Pd, Ru, Ti and Cu is included therein with its content ranging between 0 to 4 weight percent.

[0053]

[Advantages of the Invention]

According to the claims 1 and 2, an optical recording medium can be provided having excellent O/W characteristics, since the content of its recording layer is suitably specified by these claims.

[0054]

According to the claim 3, an optical recording medium can be provided having excellent O/W characteristics, since the recording layer is incorporated as one of constituent layers included in the recording medium having the content suitably specified by the claims 1 and 2.

[0055]

According to the claim 4, an optical recording medium can be provided having a suitable range of reflectivity, excellent O/W characteristics, and compatibility with the driving unit, since the optimum thickness of constituent layers is specified for respective layers.

[0056]

According to the claim 5, the speed of recording and overwriting for the optical recording medium can be improved, since the optical recording medium specified in claim 3 is formed

to be rewritable at least once at a linear recording velocity ranging from 9 m/sec to 30 m/sec.

[0057]

According to the claim 6, the recording and reading out capabilities of the optical recording medium specified by claim 1 or 2 can be further improved, since its recording layer is formed to have a composition satisfying the relation of $88 \leq c + d \leq 98$.

[0058]

According to the claims 7 and 8, the optical recording medium can be provided maintaining high reflectivity, having excellent O/W characteristics and storage durability, since the kind, and the amount of additives to be included in the metal/alloy layer of claim 4 are suitably specified.

[0059]

According to the claims 9, 10 and 11, the optical recording medium described in the claims, 1, 2, 3 and 6, can suitably be formed, since the content of the sputtering target disclosed herein either of Ag-In-Sb-Te or Ag-In-Sb-Te-Ge is suitably specified.

[Brief Description of the Drawings]

[FIG. 1]

A schematic cross-sectional view illustrating a phase-change optical recording medium according to one embodiment disclosed herein.

[Description of the Numerals]

1	:	Substrate
2, 4	:	Dielectric layer

3	:	Recording layer
5	:	Reflective layer

[Name of Document] Drawing

[FIG. 1]

[Name of Document] Abstract of the Disclosure

[Abstract]

[Object of the Invention]

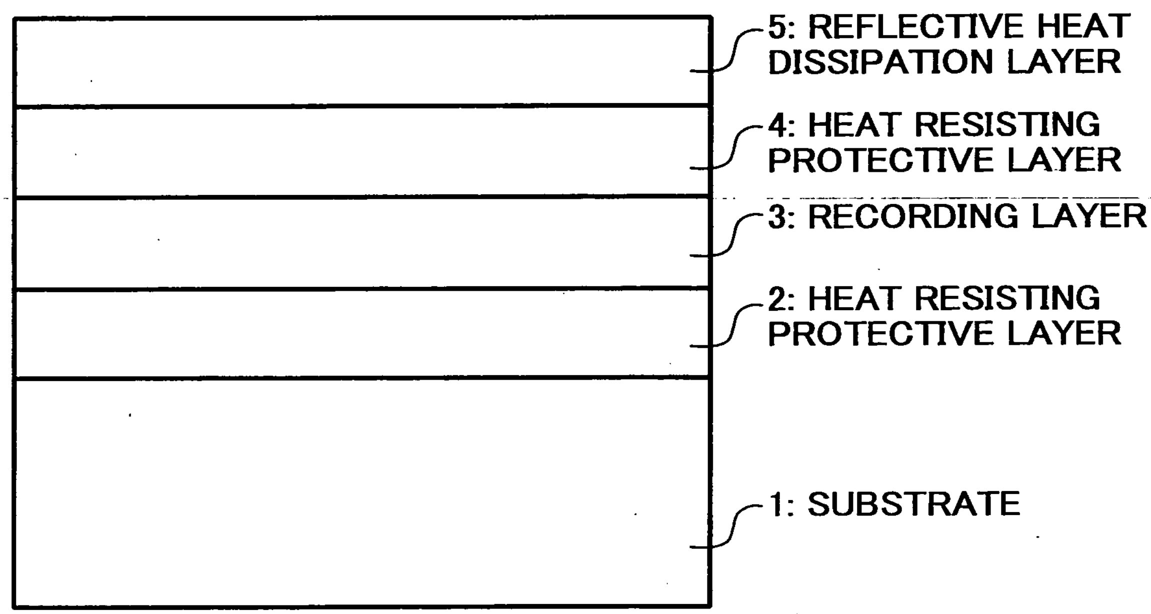
To provide an optical recording medium having suitable recording and reading out capabilities at least at a linear recording velocity ranging from 9 m/sec to 30 m/sec, and sputtering targets suitably used for realizing such optical recording medium.

[Means for Solving the Problems]

An optical recording medium comprising a recording layer containing at least materials capable of carrying out recording and erasing operations through phase changes of the materials included therein, in which the recording layer is characterized by essentially consisting of Ag, In, Sb and Te, with a proportion in atomic percent of a(Ag): b(In): c(Sb): d(Te), with $0.1 \leq a \leq 7$, $2 \leq b \leq 10$, $64 \leq c \leq 92$ and $5 \leq d \leq 26$, provided that $a + b + c + d \geq 97$.

[Selected Drawing] None

FIG. 1



5: REFLECTIVE HEAT DISSIPATION LAYER
4: HEAT RESISTING PROTECTIVE LAYER
3: RECORDING LAYER
2: HEAT RESISTING PROTECTIVE LAYER
1: SUBSTRATE